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Transport of [^{14}C]benazolin and bromide in large zero-tension outdoor lysimeters and the undisturbed field in a sandy soil

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Abstract: In order to investigate the transferability of lysimeter results to the actual field situation, a leaching study with [^{14}C]benazolin and bromide was carried out in a sandy soil. A suction base system, where soil water and solute fluxes through a lateral cross-sectional sampling area could be measured in an undisturbed field environment, was developed as reference system. Using that measuring instrument, possible artefacts of the lysimeter system could be excluded. The outflow of soil water and leaching of benazolin and bromide showed no system-related differences between the lysimeters and the undisturbed field represented by the suction base station. Higher outflow of leachate and bromide in the lysimeters could be attributable to different meteorological conditions at the lysimeter and the field station.

Keywords: lysimeter; transferability; suction base; solute transport; benazolin; sandy soil

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Pesticide leaching studies with large suction-free lysimeters are an important approach to assess the leaching behaviour of pesticides. In contrast to field studies, where only a small fraction of the entire transport system can be sampled, they provide for a complete detection of solutes that reach the sampling depth. Additionally, ^{14}C-labelled pesticides can be used with all the known advantages of the tracer technique.

However, differences between zero-tension lysimeters and the undisturbed field may affect pesticide transport and limit the transferability of the results. In particular the capillary fringe at the lysimeter ground, which is caused by the zero-tension conditions at the lower boundary, may artificially influence the soil water and solute dynamics. In addition, cracks and fissures, which may result from sampling and transport of the monoliths, may induce artificial flow of solutes. Finally, the lysimeter wall prevents lateral water and solute flux of the solute pulses applied.

In order to compare the leaching behaviour of lysimeters with that of the undisturbed field (loamy sand: 70–78% sand, 15–24% silt, 2–5% clay, <1% C_{org}), three lysimeters were used (0.8 m^2 surface, 1.3 m height), and a research station with three suction bases at a depth of 1.3 m was installed at the field site. The suction bases, which were inserted laterally into the undisturbed soil, consisted of steel frames (1.5 m wide, 1.8 m long, 0.7 m high), which were open at the front and back. Through the perforated ceiling, more than 200 suction cups were inserted into the undisturbed soil above each frame. The potential of the suction cups was permanently adjusted to a relevant value, the mean of several tensiometers at this depth. The system provided an adequate sampling technique for drainage water at a cross-sectional area as in the case of lysimeters. A capillary fringe was avoided, as well as artificial disturbances of the soil above the suction units. Lateral water and solute flow was possible, and thus the artefacts of the lysimeter system could be avoided.[1]

Bromide and [^{14}C]benazolin were applied simultaneously to the six plots of both test systems. The leachate was collected weekly and analysed for bromide concentration and ^{14}C-activity.[1]

After 2.5 years of experimentation and more than 2000 mm precipitation, between 38% and 81% of the bromide and 0.5% and 4.8% of the [^{14}C]benazolin applied was recovered in the effluent (Fig 1). Cumulative leachate and bromide outflow occurred relatively in parallel, revealing a CV (Coefficient of Variation) of 9% and 5% for the lysimeters and 21% and 22% for the suction bases. In contrast, the outflow of [^{14}C]benazolin showed great variability within both systems, resulting in a CV of 94% and 61% for the lysimeters and the suction bases, respectively. However, the mean [^{14}C]benazolin mass in the effluent was similar in both systems, whereas the mean outflows of leachate and bromide were *c*35%

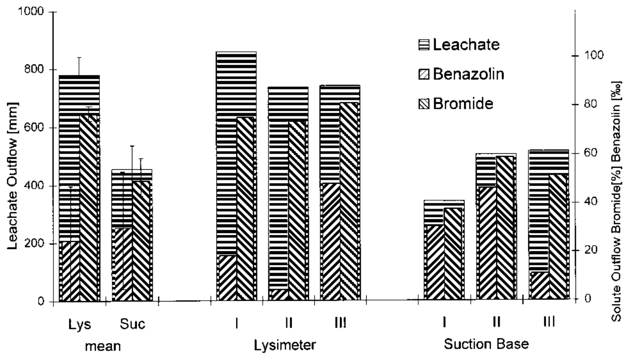

Figure 1. Cumulative leachate and solute outflow in the lysimeters and the suction bases after 2.5 years.

lower for the suction bases than for the lysimeters.

With respect to the six experimental plots of both systems, it was found that the bromide outflow revealed a high correlation with the leachate amount ($r = 0.94$); however, [^{14}C]benazolin outflow correlated neither with the drainage ($r = -0.18$) nor with the bromide outflow ($r = 0.05$).

It could be shown that the differences of the drainage (and the bromide) outflow were caused by different meteorological boundary conditions at the lysimeter and the field station which were *c*20 km apart. The average wind speed during the experiment was significantly higher at the field station than at the lysimeter station ($1.5\,\mathrm{m\,s^{-1}}$ versus $0.9\,\mathrm{m\,s^{-1}}$) as was also the average solar radiation ($121\,\mathrm{W\,m^{-2}}$ versus $99\,\mathrm{W\,m^{-2}}$). This can be explained by shading effects of the surrounding wire mesh cage and adjacent buildings.[1,2] When estimating the potential evapotranspiration with the Penman Equation, it was found that the evapotranspiration at the field station could be expected to be more than 23% higher than the lysimeter station.

Since no system-related differences between the lysimeters and the suction bases were found, it may be concluded that lysimeters were well-suited to examine the leaching behaviour of solutes in the sandy soil used for the experiments. Nevertheless, the variability of the [^{14}C]benazolin outflow demonstrated that it is not possible to assess the leaching tendency of a pesticide using only one lysimeter (of that given size). Several replicates are necessary to cover the variability of the physical and biochemical factors in the soil.

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Resistance to benzimidazole can be caused by changes in β-tubulin isoforms

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Abstract: The summary reports work that indicates that resistance in *Rhynchosporium secalis* to benzimidazole fungicides could result from substitution of the normal wild-type *benA* β-tubulin gene by other β-tubulin isoforms.

Keywords: resistance; *Rhynchosporium secalis*; benzimidazoles; β-tubulin isoforms

1 INTRODUCTION

Benzimidazole fungicides bind to β-tubulin and affect microtubule function. Field resistance to this group of fungicides in pathogen populations has been limited to mutations at codons 198 and 200 of the β-tubulin (*benA*) gene, although amino acid substitutions conferring benzimidazole resistance exist at another seven codon positions in laboratory-induced mutants.[1] In monitoring studies of field populations of the barley leaf scald pathogen *Rhynchosporium secalis* Davis we have identified two mutations linked to benzimidazole resistance. At codon 198 the change of **GAG** to **GGG** substitutes glycine for glutamic acid and at codon 200 the change of **TTC** to **TAC** substitutes tyrosine for phenylalanine. However, a point mutation generated in the laboratory substituting lysine for glutamic acid at codon 198 (**GAG** to **AAG**), has not been identified in the field and may carry a pathogenicity penalty.[2] As a first step to determine the effect of specific mutations on pathogenicity of *R secalis*, a wild-type benzimidazole-sensitive strain was transformed with an altered $\mathbf{GGG}_{198}$ gene.

2 EXPERIMENTAL

Strain 810 was transformed with vector pRSTUB3,1[3] by the protoplast method[4] and transformants selected on lima bean agar amended with the benzimidazole carbendazim ($1\,\mu\mathrm{g\,ml^{-1}}$). Two transformants, J2 and J3, were obtained and fungicide sensitivity levels assessed. In comparison to 810, both transformants have decreased sensitivity to carbendazim (Table 1), similar sensitivity levels to the *N*-phenylcarbamate dithiofencarb, but are at least 25-fold less sensitive to another carbamate, methyl *N*-(3,5-dichlorophenyl)carbamate (MDPC). Pathogenicity was determined by inoculating 20-day-

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